***If you are using a printed copy of this procedure, and not the on-screen version, then you MUST make sure the dates at the bottom of the printed copy and the on-screen version match.***
***The on-screen version of the Collider-Accelerator Department Procedure is the Official Version. Hard copies of all signed, official, C-A Operating Procedures are kept on file in the C-A ESHQ Training Office, Bldg. 911A***

C-A OPERATIONS PROCEDURES MANUAL

# 14.14 C-A EMS Process Assessment for NASA Space Radiation Laboratory (C-A-595-BAF)

Text Pages 2 through 8

Attachment

Hand Processed Changes

| HPC No. | Date | Page Nos. | Initials |
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Approved: ***Signature on File*** _____
Collider-Accelerator Department Chairman Date

P. Cirnigliaro, M. Van Essendelft

**BROOKHAVEN NATIONAL LABORATORY**
**PROCESS ASSESSMENT FORM**

## I. General Information

| | | | | |
|---|---|---|---|---|
| Process ID: | CAD-595-BAF | | | |
| Process Name: | NASA Space Radiation Laboratory | | | |
| Process Flow Diagrams: | CAD-595-BAF-01through-06 | | | |
| Process Description: | This process includes the maintenance and operations for the NASA Space Radiation Laboratory (NSRL) managed by the Collider-Accelerator Department located in Buildings 956, 957, and 958. The NSRL is utilized for Radiobiological experiments. The NSRL supports an Animal Facility located in laboratories A1 and A2, typically housing rats and mice. Cages and animal watering bottles are washed in the Wash Room. The environmental aspects associated with these operations are liquid discharges and radioactive waste. Flow diagrams detail the disposal practices.<br><br>The NSRL also supports Medical Facilities located in Laboratories C1, C2, and the Common use Lab. Medical research utilizing animal and human bodily materials is conducted within the various labs. Waste generated from medical research activities include non-regulated medical waste and regulated medical waste as defined by NYSDOH and NYSDEC.<br><br>Incorporated into the NSRL facility is a small photographic laboratory where film developing is performed in support of sample placement in the accelerator beam line.<br><br>In addition to experiment operations, magnets and power supplies are used to transport beam to the experiment.<br><br>Flow Diagrams provide more detail on the waste management operations. | | | |
| Dept./Div.: | Collider-Accelerator Department | | | |
| Dept. Code: | AD | | | |
| Building(s): | 956, 957, & 958 | | | |
| Room(s): | N/A | | | |
| Point of Contact: | E. Lessard | X -4250 | J. DeBoer | X-4668 |
| Originally Prepared by: | P.Cirnigliaro & M. Van Essendelft | Original Reviewers: | J. DeBoer<br>G. Goode<br>R. Karol<br>E. Lessard | |
| Initial Release Date: | 7/13/02 | | | |

## II. Detailed Process Descriptions and Waste Determination

The NASA Space Radiation Laboratory (NSRL) at Brookhaven National Laboratory, in collaboration with NASA, is a experimental facility and accelerator required to take advantage of heavy-ion beams from the Brookhaven Alternating Gradient Synchrotron (AGS) Booster accelerator for radiation effect studies for the space program. Radiation fields encountered in space may cause deleterious effects in humans, and these effects are of special concern for prolonged space missions beyond the protective terrestrial Magnetosphere. Before such missions can be undertaken, a much more detailed understanding of these effects is required to allow planning and implementation of protective countermeasures.

The NSRL buildings, 956, 957, and 958, house the Animal Facility, the Medical Research Laboratories and a Photographic Laboratory utilized in the radiobiological experiments. The Animal Facilities and the Medical Research Laboratories are separated into two processes. The Process Flow Diagrams for the Animal Facility are available in the Process Flow Diagram C-A-595-01. The Medical Research Laboratories are available in the Process Flow Diagram C-A-595-02, and the Photography Laboratory in Process Flow Diagram C-A-595-03. The Process Flow diagram for the Water Systems is AGS-004-CWS-23. The Process Flow diagram for Activated Soils and Airborne Radionuclides is C-A-595-05&06

**Regulatory Determination of Process Outputs**

### 1.0 Animal Facility

There are two animal rooms A1 and A2 available for short term housing needs of small healthy animals. Rats and mice are housed in metal or polycarbonate cages. Food and water may be placed in the cages depending upon the experimental protocol. Bedding material used is typically ¼" ground corncob material. Feces and urine are either cleaned up with the bedding material or if no bedding material is used, there are drip pans beneath the cage, which are washed into the sanitary sewer system. Cages and bottles are cleaned in the Wash Room and prepared for reuse. The area consists of the dirty area where the cages are brought in for cleaning and the clean area where cages are restocked with bedding and sent back for reuse. The bedding contaminated with feces and urine are removed as non-hazardous waste. Cages and bottles are washed and the effluent is discharged into the sanitary sewer. Floor washing is done on a regular basis. Floors in the Animal Facility and Wash Room are washed down with the disinfectant, Quatricide PV-15. All medical waste generated during the experiments is the responsibility of the BNL Medical Department.

| Waste ID | Waste Description | Determination/Basis | Waste Handling | Corrective Action Required |
|---|---|---|---|---|
| 1.1 | animal bedding, urine and fecal material | Non-hazardous solid waste as determined by process knowledge | Waste is transferred to a dumpster and discarded as regular trash | None |
| 1.2 | Non-radioactive body fluids and disinfecting solution/ wash water | Non-hazardous / non radioactive liquid waste as determined by process knowledge. | Liquid Waste is discharged to the sanitary sewer system. | None |

## 2.0 Medical Facilities Laboratory

There are three Medical use laboratories located at NSRL, C1, C2, and the Common Lab. Medical research utilizing animal and human materials is conducted within the various laboratories. Medical experiments undergo an Experimental Safety Review prior to initiation of the experiment. As part of the review and approval process, the anticipated medical waste (in addition to all other waste) is identified and the appropriate waste management procedures are determined for the experiment. Medical waste includes non-regulated medical waste and regulated medical waste (RMW) as defined by the NYSDOH and NYSDEC statutes, regulations and guidelines. The definition of regulated medical waste includes:

- Cultures and Stocks (of agents infectious to humans and associated biologicals)
- Human Pathological Wastes (excluding urine and fecal materials submitted for other than diagnosis of infectious diseases)
- Human blood and Blood Products
- Sharps (or other sharp materials that may cause puncture or laceration wounds)
- Animals Waste (from animals known to be contaminated with infectious agents)

As indicated above, contamination with infectious agents is key to identifying regulated medical waste. A more detailed description of waste managed as regulated waste can be found in the Medical Department Guideline for “Handling & Disposal of Regulated Medical Waste” and/or the Regulated Medical Waste subject area. The regulated medical waste generated at NSRL would be limited to sharps.

Non-regulated medical waste generated at NSRL includes the following:

-cultures and stocks which have not been contaminated with infectious agents; animal waste which has not been contaminated with infectious agents

The research performed at NSRL uses materials that have not been contaminated with infectious agents. All materials used by experimenters are transferred to Medical Department for proper disposal.

Periodically the Laboratory floors and walls are washed down with Quatricide PV-15.

| Waste ID | Waste Description | Determination/Basis | Waste Handling | Corrective Action Required |
|---|---|---|---|---|
| 2.1 | Animal/human cells, media, and non-primate serum. | Non-hazardous liquid waste as determined by process knowledge. | Waste is mixed with bleach allowed to stand overnight and then discharged to the sanitary sewer system. | None |
| 2.2 | Sharps | Regulated Medical Waste | Sharps materials are placed within Sharps containers Sharps container are transferred to Medical Department for disposal as per Medical Department Guidelines. | None |
| 2.3 | Biological materials, equipment and chemicals used by experimenters. | Non-Regulated Medical Waste | Transferred to Medical Department for proper disposal | None |
| 2.4 | disinfecting solution/ wash water | Non-hazardous / non-radioactive liquid waste as determined by process knowledge. | Liquid Waste is discharged to the sanitary sewer system. | None |

**3.0 Photography Laboratory**

The photography laboratory contains an automatic film processor. Radiographic film is used in the determination of subject alignment within the accelerator beam. The film is exposed during

this alignment process. Films are then developed in the automatic processor and waste chemicals are stored within the processor equipment. Wastewater from the rinse bath is discharged to the sanitary sewer. Vapors from the process chemical baths are emitted to the ambient air and then vented to the outside air via the room ventilation system. Empty plastic containers, used KimWipes and scrap film, if generated, are discarded in the regular trash. The used chemicals are hazardous liquid waste, which is transferred to Waste Management Division for proper disposal.

| Waste ID | Waste Description | Determination/Basis | Waste Handling | Corrective Action Required |
|---|---|---|---|---|
| 3.1 | Spent developer | Non hazardous as determined by MSDS | Waste to be sent to the HWMF for disposal as an industrial waste | None |
| 3.2 | Spent fixer | Hazardous liquid waste as determined by process knowledge | Waste to be sent to the HWMF for disposal as hazardous waste | None |
| 3.3 | Spent rinse water | Analyses conducted on running rinses from similar operations have shown silver levels to be in the range of 50-60 ppb. | Sanitary sewer. While this exceeds the SPDES effluent release limit at the STP (15 ppb), ESD has approved releases of small quantities to sanitary since they would not put a burden on the STP. | None |
| 3.4 | Vapors | Non-hazardous vapors as determined by process knowledge | Vapors are emitted to the room air then vented to the outside air | None |

| Waste ID | Waste Description | Determination/Basis | Waste Handling | Corrective Action Required |
|---|---|---|---|---|
| 3.5 | Empty containers, KimWipes and scrap film | Non-hazardous solid waste. Empty containers and Kim wipes as determined by process knowledge. Concerning the scrap film, TCLP analysis for metals has been conducted on x-ray film (COC 9400553), which was determined to be non-hazardous. Additionally, information from Kodak indicates photographic films and papers, both processed and unprocessed test non-hazardous by TCLP. | Waste is discarded in the regular trash | None |

**4.0 Cooling Water Systems**

The NASA Space Radiation Laboratory cooling water system, located in building 957 consists of two primary closed loops (magnet & power supply), two heat exchangers and a secondary, non-contact open system with a cooling tower (refer to process flow diagram AGS-004-CWS). It should be noted that none of the water in the NSRL cooling system would contain radionuclides in concentrations that exceed the EPA Drinking Water Standard. Heat from NSRL magnets and power supplies is transferred to a primary loop that rejects its heat load to the secondary loop via a dedicated heat exchanger. The secondary loop then rejects its heat to the atmosphere via an open cooling tower located outside of building 957. The primary loop, connected to the magnets, contains low-level activated water due to exposure to the beam. Make-up water for the cooling systems is supplied by the BNL potable water system. A backflow prevention device is used on the make-up to the primary system to prevent activated water from entering the potable water system. An ozone treatment system has been added to the NSRL cooling tower system, whereby ozone is injected into the secondary cooling water system to control bacterial growth through the oxidative property of ozone. Cooling tower blowdown and cleaning water is discharged to the BNL Sanitary system (4.1). Water vapor from the cooling tower is released to ambient air (4.2). The NSRL cooling system has two make-up water deionizer and polishing filter/deionizer loops. The water is deionized to reduce conductivity, which can create unwanted problems in the presence of intense magnetic fields. The spent make-up deionizer resin is replaced and used as fill material in shipping containers containing low-level radioactive waste. The spent polishing filter is sent off-site for disposal as low-level radioactive waste

approximately every 1 to 2 years (4.3). Spent deionizer resin is removed from cartridges and used as fill for B-12 & B-25 waste containers or transported off-site for disposal as low-level radioactive waste (4.5).

Total volume of the primary water loop for the magnets in the NSRL system is about 450 gallons and for the power supplies is about 800 gallons. The NSRL system has been constructed in accordance with Suffolk County Article 12 requirements. The NSRL pump room has a sunken floor that is sealed to act as containment in the event of a spill. In addition to the sunken floor there is an alarmed sump that is connected to an 800 gallon tank in the mezzanine level of building 957. Piping that transports water from the pump room to the magnets goes underneath the berm and in this area it is double walled and pitched into the tunnel in the event of a leak. The tunnel area also contains an alarmed sump, which also transports any spill related water to the tank, which is located in the mezzanine of the pump room.

In the event that the primary cooling water loops are drained, then the activated water is collected in the C-A tanker trailer for recycling within the system. During the colder months, because of freezing concerns, the tankers are heated causing some evaporation of the water (4.6). If the department determines the liquid to be waste it is disposed of through the Waste Management Division. The exact drain-and-replace schedule is based on sampling results.

| Waste ID | Waste Description | Determination/Basis | Waste Handling | Corrective Action Required |
|---|---|---|---|---|
| 4.1 | Cooling tower blowdown and cleaning water (w/biocide) | Non-hazardous/ non-radioactive effluent as determined by process knowledge | Wastewater is discharged to the STP through sanitary. | None |
| 4.2 | Water vapor emissions from cooling tower | Non-radioactive / process knowledge | Vapors are released to ambient air. | None |
| 4.3 | Polishing bag filters | Non-hazardous/ radioactive solid waste as determined by process knowledge/ radioactivity survey | Waste is sent off-site for disposal as low level radioactive waste | None |
| 4.4 | Make-up deionizer resin | Non-hazardous/ non-radioactive solid waste as determined by process knowledge | Spent deionizer resin is removed from cartridges and used as void space fill for B-12 & B-25 waste containers or transported off-site for disposal | None |

| Waste ID | Waste Description | Determination/Basis | Waste Handling | Corrective Action Required |
|---|---|---|---|---|
| 4.5 | Activated cooling water (Below EPA Drinking Water Standard | Radioactive / process knowledge, direct analysis | Water that is collected in storage tankers is not waste and can be recycled. Liquid waste, if any, is disposed of as radioactive waste. | None |
| 4.6 | Power Supply water (Below EPA Drinking Water Standard) | Non-hazardous/non-radioactive liquid waste as determined through direct analysis | If water samples are non-radioactive then water may be disposed of via BNL storm system. | None |

**5.0 Activated Soils / Groundwater Impacts**

The principal radiation hazards associated with the NASA Space Radiation Laboratory derive from the primary beam flux and duty cycle for NSRL operations. NSRL operations can have an impact on soils and groundwater through soil activation caused by secondary radiation produced by unintended beam losses in focusing magnets. The goal of the C-AD MCR operators is to provide protons and heavy ions "on-target," without losses that occur due to incorrect beam positioning. Efforts made to ensure that the beam is on-target are referred to as beam tuning. If the beam is improperly tuned, it may strike quadropole magnets or other metal components used to guide the particles along the intended path. If the beam is out of position to only a slight degree, a magnet may absorb unintended beam energy. When this happens, a cascade of secondary particles is produced which are capable of creating radionuclides in surrounding materials. The shower of secondary particles created by primary beam losses is strongly biased in the forward direction, relative to the beam. However, a certain percentage of secondaries are also scattered in the reverse direction, leading to soil activation around the NSRL transport line, adjacent to and West of the target cave. All such interactions will occur underground.

Groundwater can be impacted only if water (from precipitation or other sources) is allowed to pass through activated soils, thereby leaching radionuclides downward through the unsaturated zone to the water table. Calculations have been performed by simulating an upstream loss by forcing protons to interact over a length of one meter in the beam pipe in a bare tunnel. Through these calculations it was determined that losses at the extraction area necessitated placing a geomembrane cap over this area to prevent water infiltration and subsequent possible leaching of tritium, and, more so, sodium-22 into the groundwater. Modeling of radionuclide production exterior to the target cave was performed and, while results did not exceed the drinking water standard, a decision was made to place a geomembrane cap over the entire area to eliminate any possible cause of future concern should beam line intensity and/or use change.

| Waste ID | Waste Description | Determination/Basis | Waste Handling | Corrective Action Required |
|---|---|---|---|---|
| 5.1 | Tritium and Sodium-22 production in soil | Radionuclide type and quantity based on computer modeling | None, cap prevents leaching and should allow radionuclides to decay in place | None |

**6.0 Airborne Radionuclide Production**

In addition to the materials listed above, activation also takes place within the immediately surrounding air as the proton beam leaves the confines of the vacuum system and crosses an air gap to reach the target. Based on calculation, typical air activation products generated include argon-41, chlorine-39, chlorine-38, sulfer-35, phosphorus-32, aluminum-28, sodium-22, oxygen-15, oxygen-14, nitrogen-13, carbon-11, beryllium-7, and tritium (6.1). Most are short-lived with half-lives on the order of minutes and have maximum predicted production rates which range from microcuries to millicuries annually. A NESHAP assessment was performed on these emissions in accordance with the requirements of 10 CFR Part 61. Given these radionuclide quantities, the dose to the maximally exposed individual of the public has been estimated using the Clean Air Act Code (CAP88-PC). The standard BNL site-specific model was utilized with 10-year average wind rose, temperature and precipitation and the most current population data. The CAP88-PC model is designed to model continuous airborne radioactive emissions that occur over the course of a year. While the actual emissions from this process will only be intermittent (when the beam is directed at the target), the radionuclide emissions were modeled as if they were released continuously (a conservative assumption). Aluminum-28, oxygen-14, chlorine-39 and chlorine-38 are not included in the model, because of their lack of affect or because they are not included in the CAP88-PC radionuclide library. However, the source terms and half-lives of these radionuclides are so small that their exclusion has no affect on the conclusions of the evaluation.

The dose to the BNL site maximally exposed individual of the public at the northeastern site boundary is $9.7 \times 10^{-6}$ mrem/yr. This calculated dose is six orders of magnitude below the 10 mrem/yr limit specified in 40CFR61, Subpart H, and a factor of ten-thousand times less than the 0.1 mrem/yr limit that triggers the NESHAPs permitting process. Therefore, no application for a permit was required for the NASA Space Radiation Laboratory and continuous monitoring of the release point is not required. Normally, the Target Room is ventilated continuously to reduce odors from the biological specimens. The ventilation system will maintain the radionuclide concentrations at insignificant values in the Target Room. If the ventilation is off and irradiations and entries are still made, the dose to an individual who spends an hour in the Target Room would be a small fraction of a mrem. Thus, there are no significant hazards from loss of Target Room ventilation.

| Waste ID | Waste Description | Determination/Basis | Waste Handling | Corrective Action Required |
|---|---|---|---|---|
|   | Airborne radionuclides from air activation and target irradiation | Radioactive / process knowledge, direct analysis | Airborne radionuclides are allowed to decay inside the target cave. | None |

## III. Waste Minimization, Opportunity for Pollution Prevention

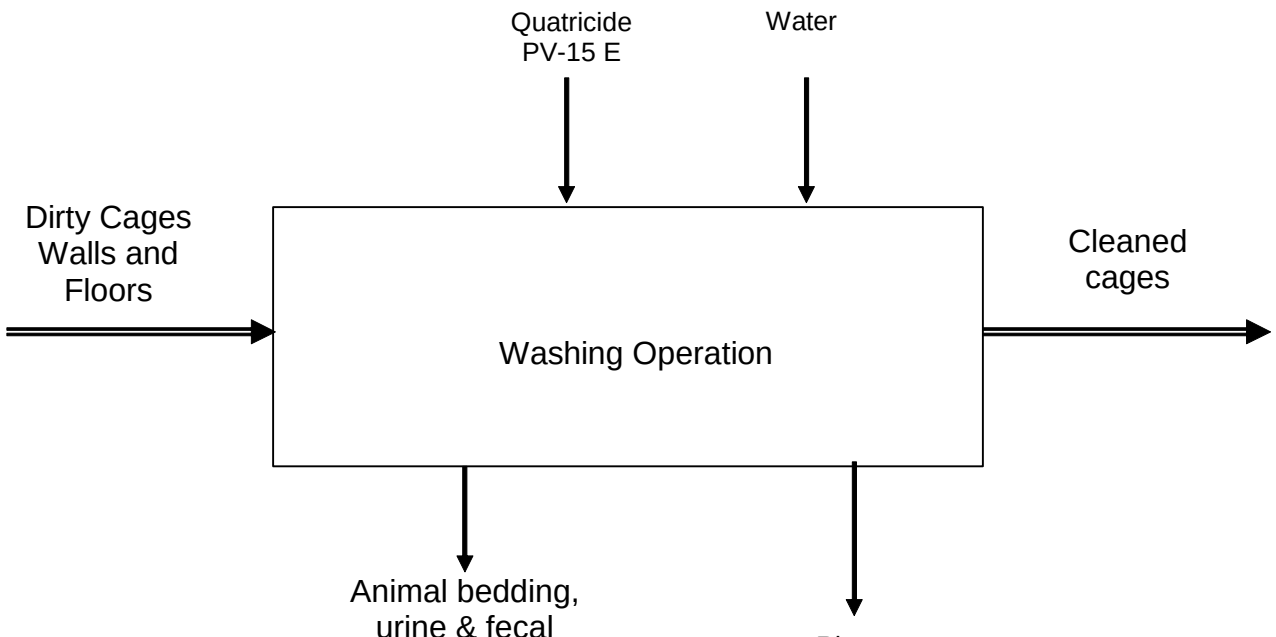
During the initial effort of baselining the Collider-Accelerator Department processes for Pollution Prevention and Waste Minimization Opportunities each waste, effluent, and emission was evaluated to determine if there were opportunities to reduce either the volume or toxicity of the waste stream. A opportunity was identified. Radiobiology experimenters have historically used radiographic film and associated wet chemistry processing to accurately position samples in the accelerator beam. Spent photographic fixer chemicals are hazardous waste. Technology now presents the use of digital positioning equipment using CCD camera systems. These systems provide, real time, direct visual feedback on beam position. The systems indicate target dose and dose uniformity while eliminating a hazardous waste steam. The experimental community has expressed reluctance to use this new technology over the historical practices and use of wet film chemistry. Efforts should be made to persuade experimenters to embrace this technology and eliminate the hazardous waste steam.

## IV. Assessment Prevention and Control

During the initial effort of baselining the Collider-Accelerator Department Assessment, Prevention, and Control (APC) Measures operations, experiments, and waste that have the potential for equipment malfunction, deterioration, or operator error, and discharges or emissions that may cause or lead to releases of hazardous waste or pollutants to the environment or that potentially pose a threat to human health or the environment were described. A thorough assessment of these operations was made and none were determined.

**ATTACHMENT 1**

**PROCESS FLOW DIAGRAMS**




Legend

- Solid Waste
- Air Emissions
- Wastewater

SS = Sanitary Sewer

Filename: 595f 01

BROOKHAVEN NATIONAL LABORATORY

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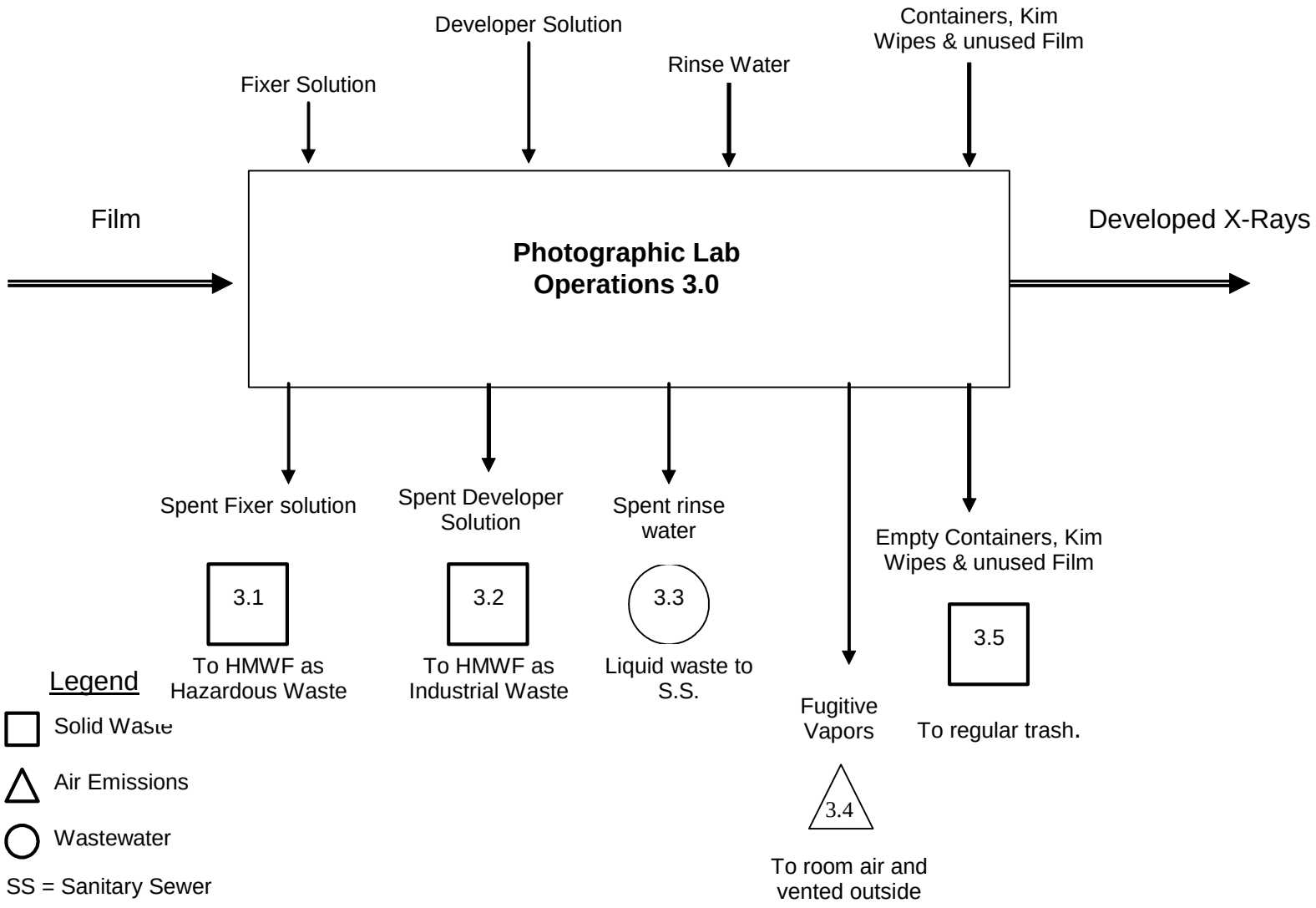
PROCESS ASSESSMENT PROGRAM

**C-AD – 958 Animal Facility**
**Process Flow Diagram**

CAD-595-BAF-01



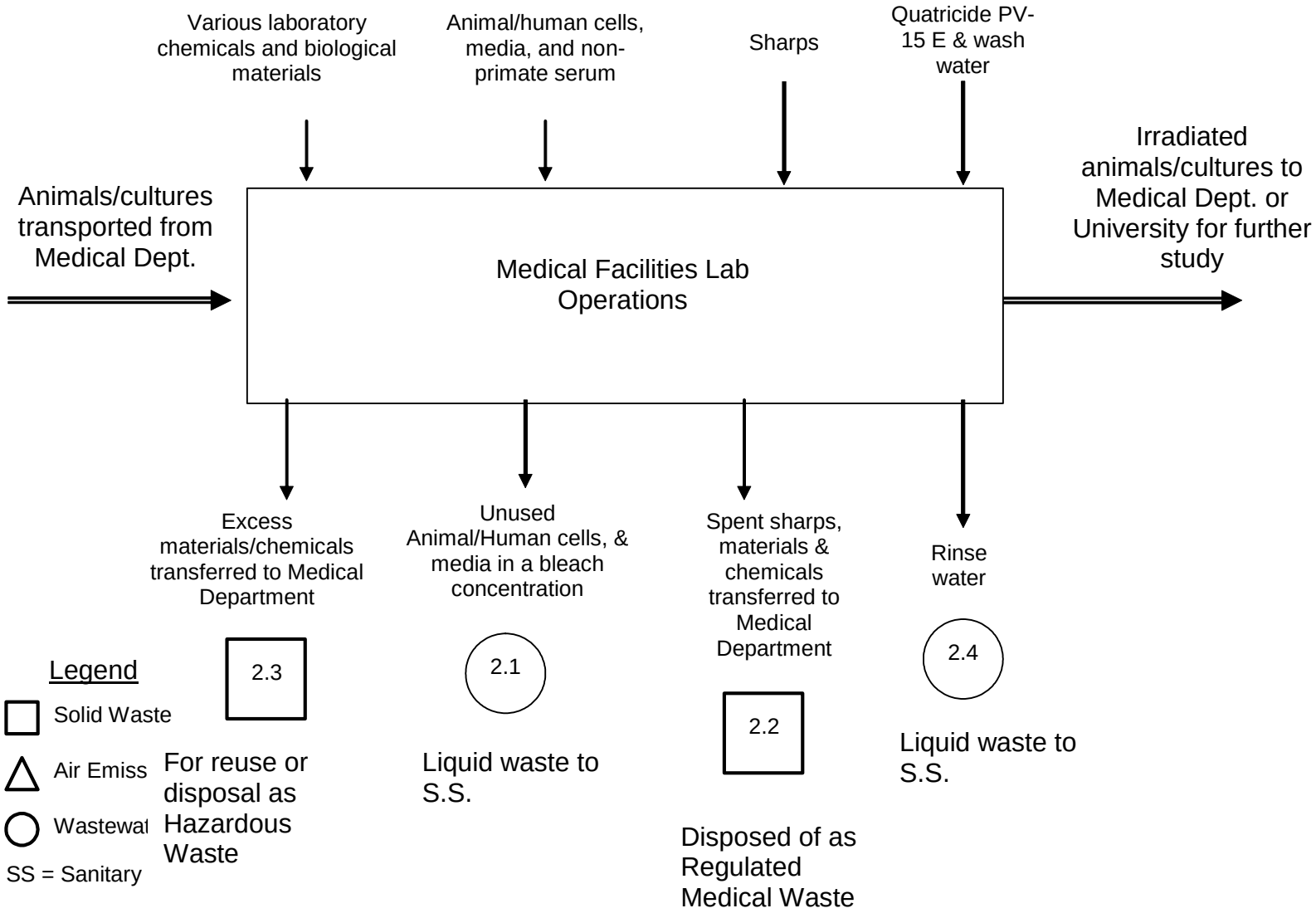

Filename: 595f 01

BROOKHAVEN NATIONAL LABORATORY

BROOKHAVEN NATIONAL LABORATORY
PROCESS ASSESSMENT PROGRAM

**C-AD – 958 Photographic Lab**
**Process Flow Diagram**

CAD-595-BAF-02

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BROOKHAVEN NATIONAL LABORATORY

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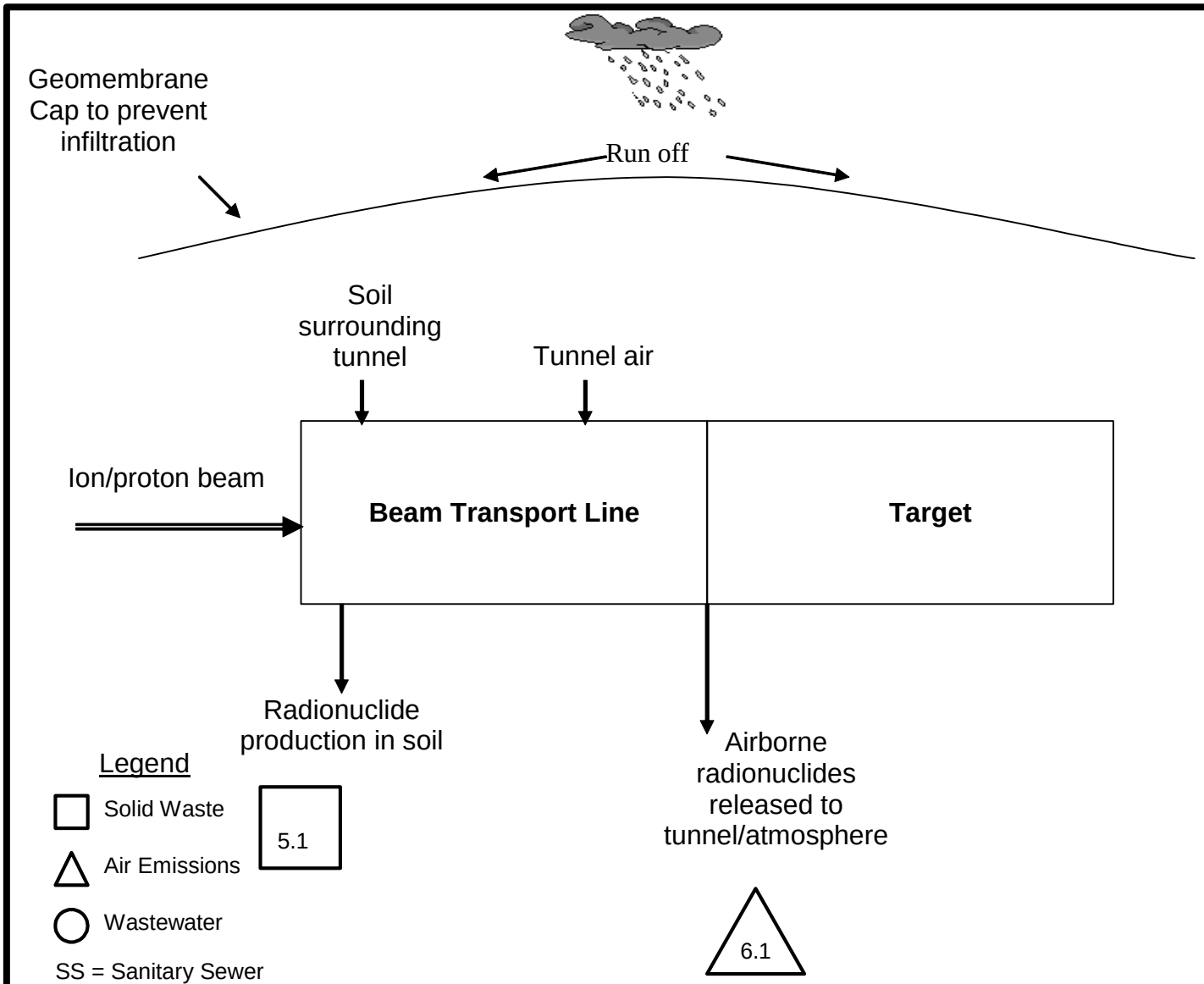
PROCESS ASSESSMENT PROGRAM

**C-AD – 958 Medical Facilities Lab**

**Process Flow Diagram**

CAD-595-BAF-03

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BROOKHAVEN NATIONAL LABORATORY
PROCESS ASSESSMENT PROGRAM

**C-AD – Booster Applications Facility**

**Process Flow Diagram**

CAD-595-BAF-05&06